Mental and emotional representations of "weight loss": free-word association networks in members of bariatric surgery-related social media communities

Gero, Daniel ; File, Bálint ; Hinrichs, Noreen ; Mueller, Matteo ; Ulbert, István ; Somogyvári, Zoltán ; Bueter, Marco

Abstract: Background: Mindset and communication barriers may hinder the acceptance of bariatric surgery (BS) by the eligible patient population. Objectives: To improve the understanding of expectations, opinions, emotions, and attitudes toward weight loss among patients with obesity. Setting: Switzerland, Germany, Austria. Methods: Survey data collected from BS-related social media communities (n = 1482). Participants were asked to write 5 words that first came to their mind about "weight loss," and to select 2 emotions, which best described their corresponding feelings. Demographic and obesity-related data were collected. Cognitive representations were constructed based on the co-occurrence network of associations, using validated data-driven methodology. Results: Respondents were Caucasian (98%), female (94%), aged 42.5 ± 10.1 years, current/highest lifetime body mass index = 36.9 ± 9/50.7 ± 8.7 kg/m2. The association network analysis revealed the following 2 cognitive modules: benefit-focused (health, attractiveness, happiness, agility) and procedure-focused (effort, diet, sport, surgery). Patients willing to undergo BS were more benefit-focused (odds ratio [OR] = 2.4, P = .02) and expressed more "hope" (OR = 142, P < .001). History of BS was associated with higher adherence to the procedure-focused module (OR = 2.3, P < .001), and with increased use of the emotions "gratitude" (OR = 107, P < .001), "pride" (OR = 15, P < .001), and decreased mention of "hope" (OR = .03, P < .001). Conclusion: Patients with obesity in our study tend to think about weight loss along 2 cognitive schemes, either emphasizing its expected benefits or focusing on the process of achieving it. Benefit-focused respondents were more likely to consider BS, and to express hope rather than gratitude or pride. Novel communication strategies may increase the acceptance of BS by incorporating weight loss-related cognitive and emotional content stemming from patients' free associations.

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Surgery for Obesity and Related Diseases

Mental and emotional representations of "weight loss": free-word association networks in members of bariatric surgery-related social media communities

--Manuscript Draft--

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Cover Letter

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To

Prof. Harvey Sugermann, MD

Prof. Raul Rosenthal, MD

Co-Editors-in-chief

Surgery for Obesity and Related Diseases

Zürich, 16th September 2019

Dear Professor Sugermann, dear Professor Rosenthal,

We herein submit our manuscript entitled "*Mental and emotional representations of "weight loss": free-word association networks in members of bariatric surgery-related social media communities"* for publication in 'Surgery for Obesity and Related Diseases' as *Integrated Health Article*.

Our aim was to provide a patient-centered perspective to improve communicational strategies with bariatric candidates by mapping the mental and emotional representation of the term "weight loss" in patients with obesity and/or history of bariatric surgery. We used free word associations networks combined with a novel data-driven analytical method, developed and validated earlier by our co-authors. We disseminated the invitations for participation to our online survey within bariatric surgery related Facebook groups, leading to a large study cohort with complete answers (n = 1482). The association network analysis revealed two distinct cognitive modules: benefit-focused (most frequent associations: health, agility, attractiveness) and procedure-focused (most frequent associations: sport, diet, effort).

We believe that our findings may serve as basis to improve patient-centered communication strategies and therefore may be highly relevant for the readers of 'Surgery for Obesity and Related Diseases'.

The study was presented in part at the 24th World Congress of the *International Federation for the Surgery of Obesity and Metabolic Disorders* in Madrid, Spain, on 5th September 2019. This manuscript has not been previously published or submitted elsewhere for publication.

UniversitätsSpital
Zürich

**Klinik für Viszeral- und
Transplantationschirurgie**

The manuscript has been approved by all authors. The study was entirely supported by the University of Zürich, without any external funding. The study could not have been achieved without a multi-disciplinary multi-national collaboration between surgeons and bionic engineers, which justifies the involvement of 7 co-authors.

We would be most grateful if our manuscript was considered for publication in 'Surgery for Obesity and Related Diseases'. Please do not hesitate to contact us for further information.

Yours sincerely,

Prof. Marco Bueter, MD, PhD

*Author Disclosure

SURGERY FOR OBESITY AND RELATED DISEASES (SOARD)
Author Disclosure of Relevant Financial Relationships

3.09.19

NAME: Marco Bueter, MD, PhD (corresponding author)

TITLE OF ARTICLE: Mental and Emotional Representations of "Weight Loss": Findings from a Survey Using Free-word Association Networks in Bariatric Surgery-related Social Media Communities.

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Reviewer Suggestions

Manuscript

Gero, File et al. Mental and emotional representations of "weight loss": free-word association networks in members of bariatric surgery-related social media communities. *Surgery for Obesity and Related Diseases.* 2019

Reviewer Suggestion #1

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Point to Point reply

Ms No.: SOARD-19-485R1

Title: Mental and emotional representations of "weight loss": free-word association networks in members of bariatric surgery-related social media communities

We would like to thank the editor and both reviewers for their interest and critical evaluation of our manuscript. Please find below our point-to-point replies.

We remain available for any further questions or comments.

Associate Editor

Comment #1: The respondents are 98% Caucasian and 94% female yet the manuscript's conclusions focus on attitudes of people with obesity. The findings really can only speak to the thoughts/attitudes of White women with obesity and this should be strongly tempered throughout.

Our reply: This is now emphasized in the first paragraph of the Discussion, as well as in the Limitations. We also updated the Supplemental Table 1, which now contains detailed demographic comparison of all subgroups.

Comment #2: Please add more about the demographic questions. How was BMI determined?

Our reply: We added the following paragraph to Methods:

"*Basic Demographics*

Respondents were asked to self-report their age, sex, ethnicity, civil status, height, maximal and current body weight, past or planned bariatric operations, previous non-surgical weight loss attempts and their social interactions with bariatric patients. Body mass index (BMI) was calculated by the investigators based on the anthropometric data provided by the participants."

Comment #3: How were the basic emotions selected?

Our reply: The selection of the emotions was largely built on the ten basic emotions of Izard (Izard, 1977) and the eleven pairs of positive and negative emotion pairs of Robinson (Robinson, 2008 – this reference has now been added). Respondents could choose two out of the 20 emotions to label for each of their own free word associations. Although each emotional label had an opposite pair, the labels did not appear as opposites in the questionnaire. The same emotional labeling process has been applied successfully in our recent validation study (File et al, 2019, doi: 10.3758/s13428-018-1090-z).

Comment #4: Reviewer 2 questioned the validity of the Figure Rating Scales in this population and more information should be provided. These figures likely have a ceiling effect in this population and a full range of scores aren't possible. Please spell out BID when first discussed. A discrepancy between a current and ideal body size may not be indicative of BID in this population as it may reflect current BMI versus health-related expectations. Indeed using a discrepancy score using these figures for BID came from the literature in normal weight women and those with more traditional eating disorders (e.g., anorexia). Similarly, the finding that the discrepancy is greater in those with higher BMI's seems rather tautological.

Our reply: Thank you for this important comment, which we now mention in the Methods. Although developed for the "normal weight" general population, the Stunkard rating Scale has been regularly used in the context of obesity / bariatric surgery. A study published earlier in SOARD has also used the Stunkard scale:

Ratcliff MB, Eshleman KE, Reiter-Purtill J, Zeller MH. Prospective changes in body image dissatisfaction among adolescent bariatric patients: the importance of body size estimation. Surg Obes Relat Dis. 2012;8:470-5 (this reference has now been added).

Indeed, BID score in the bariatric population may reflect current BMI versus health-related expectations. We found a moderate correlation (r= 0.57) between current BMI and the BID score. To better investigate the Editor's concern, we now correlated health related expectation (expected body image) and current body image with the current BMI value and updated the Results accordingly:

"Overall, current BMI showed a) a strong correlation with BID (Pearson's $r = 0.6$, $P < 0.001$, Supplemental Fig. 4), b) an even stronger correlation with current body image ($r = 0.77$, $P < 0.001$) and c) a weaker correlation with the expected body image ($r = 0.42$, $P < 0.001$)."

According to these results, health related expectations show a lower correlation with the BMI than the current body image. We conclude that current and expected body image have a significant relationship with the current BMI, but to a different extent.

Comment #5: I'm curious about the subset who is "not interested in BS". They seem unusual since if they were truly uninterested why would they be in social medial groups for bariatric surgery? More discussion of these individuals is warranted.

Our reply: We added the following subsection on this subgroup in Results:

"Respondents who would not consider to undergo BS

Out of the 409 respondents without prior BS, 66 stated to have no interest to undergo BS. This subgroup had a mean age of 43.6 years and consisted of Caucasian (91%) females (92%) with a BID of 2.2 who managed to lose weight non-surgically (highest lifetime BMI: 45.4±8.3 kg/m^2, current BMI: 37.9±8.8 kg/m^2). Only 53% of this group had regular contact with BS patients."

and to Discussion:

"A subgroup of the respondents stated not to be interested to undergo BS, nevertheless, by following BS-related social media they manifested interest towards BS and seem to be seeking facts and/or patient narratives to assist their health-related decisions. "

Comment #6: The completion rate is noted as 67.1% but those are individuals who went to the landing page. How many people visit these social media sites?

Our reply: This question is hard to answer because we do not have exact data. As stated in Methods, the Adipositas Zürich website has 4100 followers and the Adipositas Chirurgie - Fragen und Antworten' has 1500. We encouraged visitors to share the link of the questionnaires within their own networks. The original invitation to participate on the Facebook wall of the Adipositas Zurich group was shared 113 times. We believe that it is accurate to report the completion rate only among those who actively clicked on the invitation and started to read the questionnaire on the landing page.

Comment #7: Please use a term like sub-optimal outcome rather than "failure" when discussing weight loss as it is less pejorative

Our reply: : "Failure" was used in relation with weight loss in two sentences. These two sentences have been rephrased as follows:

"According to a Brazilian study in patients experiencing postbariatric weight regain, the feeling of gratitude toward BS remained, whereas pride was replaced by a feeling of sub-optimal outcome and low self-esteem [29]."

"However, unrealistic expectations can be responsible for the cycle of sub-optimal outcomes and renewed efforts to achieve self-change (i.e.: false-hope syndrome, "yo-yo effect")[24]."

REVIEWER 1

Comment #1: Line 52 - suggest "incorrect" instead of "wrong" information

Our reply: Corrected.

Comment #2: Line 77 - suggest inclusion of adults with obesity "seeking or post surgery" since there is a whole group not interested/seeking surgery that are not included here

Our reply: The sentence has been corrected: *"We conducted an anonymized online survey to understand how adults with severe obesity (those who seek BS, postbariatric patients, and those who are not interested to undergo BS) perceive weight loss."*

Comment #3: Line 100 - successfully applied 'earlier' (I think you mean in earlier studies, or in prior work?)

Our reply: In "a recent study" - we have now rephrased this sentence.

REVIEWER 2

Comment #1: Line 40: the first line seems strongly worded - "Patients with obesity tend to think…" Can this be tempered a bit? (e.g., Patients with obesity in our study…)

Our reply: Done.

Comment #2: Line 54: is this suboptimal cooperation or suboptimal communication between primary care physicians and bariatric centers? Just clarifying!

Our reply: This sentence has been rephrased to:

"Mindset and communication barriers seem to influence the diffusion of BS: lack of information, incorrect information, and stigmatization of individuals with obesity have proven to contribute to sub-optimal use of health care by the eligible patients and to insufficient cooperation between primary care physicians and BS centers [3, 4]."

Comment #3: Body Image Dissatisfaction: Has the Stunkard Figure Rating Scale been validated in the use of people with obesity? I am also unclear about how the analysis for BID related to the overall aims of the study.

Our reply: Please read our reply to Associate Editor's Comment#4 on the use of the Stunkard scale in the context of obesity. We hypothesized that BID may influence the cognitive representation of weight loss, however, as shown in Table 1, the BID scores were similar between the Benefit-focused and Procedure-focused groups. Body image is an important indicator of patients' wellbeing after BS [ref#27] and was higher in participants who planned to undergo BS, compared to those who did not, or already had BS (excerpt from Discussion).

Comment #4: Are there any a priori hypotheses?

Our reply: This is the first time we used social media to recruit respondents for a bariatric surgery related study. We had troubles to estimate the expected cohort size and demographic composition of respondents, making it difficult to draft a priori hypotheses. Additionally, the free word association technique is a data-driven explorative analysis. It has the advantage to explore cognitive representations beyond preconceptions, but it is almost impossible to guess the number and content of the evolving semantic groups. Therefore, our hypotheses were only related to the emotional labels of the associations.

The following amendments have been added to the Introduction, Results and Discussion:

"We hypothesized that BS had a "positive" impact on the emotional labeling of *weight loss* related free word associations."

"Postbariatric patients had a significantly higher proportion of positive emotional labels than non-operated adults with obesity (79% vs 75%, $t(1480)=1.82$; $P = 0.002$, $d=0.18$). "

"In line with our hypothesis, history of BS favored the use of positive emotional labels, however, the effect size was rather small. In fact, all respondents selected mainly positive emotions to label their associations. Remarkably, patients willing to undergo BS were more likely to express *hope*, while patients after BS expressed *gratitude* and *pride* more frequently, suggesting that BS may fundamentally change the individuals' affective connection with weight loss."

Comment #5: Line 100/101: Are there any other published studies to use this method for emotional labeling?

Our reply: Yes, our group recently published a methodological validation study: File et al, 2019, doi: 10.3758/s13428-018-1090-z. Please see our reply to the Associate Editor's Comment#3.

Comment #6: Consider demographic tables for the following:

a. ≥/< 35 BMI
b. With interest for BS vs no interest
c. With BS vs without

These may provide clarification for the existing Table 2a and 2b

Our reply: Thank you for this comment. This information is available in the Supplemental Table 1, which has been updated in this new version to fully respond to the Reviewer's comment.

Comment #7: Table 2A: were there any demographic differences between the two groups (Respondents with ≥Class Obesity and Respondents with prior bariatric surgery)?

Our reply: Demographic differences between subgroups are shown in Supplemental Table 1. "Respondents with ≥Class II Obesity" and "Respondents with prior bariatric surgery" are subgroups of the entire cohort containing 408 overlapping individuals (those who had ≥Class II Obesity and also had prior bariatric surgery). In the first logistic regression of the "old" Table 2A, the reference was the subgroup of respondents <Class II Obesity, while in the second one, those without prior BS. We re-organized this Table and its legends to increase clarity.

Comment #8: Are there any more clinical implications beyond (Lines 255-258)?

Our reply: We updated this section, which now reads as:

"…this study provided a comprehensive structure of adults' with obesity free expressions about weight loss, enhancing our understanding of patients' priorities and contributing to the improvement of health care-related communicational schemes. Discrepant expectations may significantly increase postoperative dissatisfaction with body image and decrease the extent of achievable weight loss [33], therefore setting realistic preoperative expectations and stepwise postoperative goals are crucial. Our findings also promote the collaborative approach between healthcare providers to support evidence-based treatments of obesity [34]."

Other applied implications are mentioned later in the same paragraph:

"Consequently, the network-based map of associations to weight loss presented in this study may serve as a navigational tool for caregivers, policy actors and researchers to better identify patients' implicit interest toward weight loss and to design new interventions aiming to tackle mindset barriers in the acceptance of BS among patients with obesity [38]".

"…the relevant positioning of "weight loss" can influence large groups of people with obesity and change social norms [39]. Once a mindset has been primed or activated, there is an increased likelihood that it will be used in upcoming tasks to interpret new information and to define subsequent actions [24]."

Comment #9: If this group is looking to expand on this work, consider examining cognitive schemas in primarily care providers; I wonder how this may affect referrals!

Our reply: Thank you, we fully agree and already started to brainstorm on the next steps.

Title

Mental and emotional representations of "weight loss": free-word association networks in members of bariatric surgery-related social media communities

Authors

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Manuscript category: Integrated Health Article

Communication: The study was presented in part at the 24th International Federation for the Surgery of Obesity and Metabolic Disorders World Congress on 5th September 2019 in Madrid, Spain, and at the 106th Annual meeting of the Swiss Society of Surgeons on 17 May 2019 in Bern, Switzerland.

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Running title: Mental and emotional representations of weight loss

Title

Mental and emotional representations of “weight loss”: free-word association networks in members of bariatric surgery-related social media communities

Authors

Blinded

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Funding: This work was supported by the assistant-professorship research grant awarded by the **Blinded** to Prof. Dr. med. **Blinded**, PhD; **Blinded**, MSc was supported by the **Blinded** New National Excellence Program of the **Blinded**.

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Running title: Mental and emotional representations of weight loss

Abstract

Background: Mindset and communication barriers may hinder the acceptance of bariatric surgery (BS) by the eligible patient population.

Objectives: To improve the understanding of expectations, opinions, emotions and attitudes toward weight-loss among patients with obesity.

Setting: Switzerland, Germany, Austria.

Methods: Survey data collected from BS-related social media communities (N=1482). Participants were asked to write 5 words that first came to their mind about "weight loss", and to select 2 emotions which best described their corresponding feelings. Demographic and obesity-related data were collected. Cognitive representations were constructed based on the co-occurrence network of associations, using validated data-driven methodology.

Results: Respondents were Caucasian (98%), female (94%), aged 42.5±10.1 years, current/highest lifetime body mass index=36.9±9/50.7±8.7 kg/m^2. The association network analysis revealed two cognitive modules: benefit-focused (health, attractiveness, happiness, agility) and procedure-focused (effort, diet, sport, surgery). Patients willing to undergo BS were more benefit-focused (Odds ratio (OR)=2.4, P=0.02) and expressed more 'hope' (OR=142, P<0.001). History of BS was associated with higher adherence to the procedure-focused module (OR=2.3, P<0.001), and with increased use of the emotions 'gratitude' (OR=107, P<0.001), 'pride' (OR=15, P<0.001), and decreased mention of 'hope' (OR=0.03, P<0.001).

Conclusion: Patients with obesity in our study tend to think about weight loss along two cognitive schemes, either emphasizing its expected benefits or focusing on the process of achieving it. Benefit-focused respondents were more likely to consider BS, and to express hope rather than gratitude or pride. Novel communication strategies may increase the acceptance of BS by incorporating weight loss-related cognitive and emotional content stemming from patients' free associations.

Keywords

Bariatric Surgery; Weight loss; Free-word Association; Network; Obesity; Emotional valence; Mindset; Motivation; Body image dissatisfaction

Introduction

Bariatric surgery (BS) is currently the most effective modality in the treatment of severe obesity and related diseases [1]. Despite its growing worldwide popularity as a treatment option, BS is rather underused by the eligible patient population [2]. Mindset and communication barriers seem to influence the diffusion of BS: lack of information, ~~wrong~~ incorrect information, and stigmatization of individuals with obesity have proven to contribute to sub-optimal use of health care by the eligible patients and to insufficient cooperation between primary care physicians and BS centers [3, 4]. ~~Suboptimal cooperation between primary care physicians and bariatric centers~~This may also hinder the identification and referral of eligible patients and undermine optimal postbariatric follow-up [4].

Available literature on motivational drivers in favor of seeking BS remains scarce and stems mainly from small cohorts [5-7]. Nevertheless, corroborative evidence shows that the willingness to improve health is the cornerstone for seeking BS, contextualized with psychological, emotional, environmental and social factors [8, 9]. Within the developing framework of person-centered care, the patients' narrative is a key factor in improving decision-making [10]. However, due to the sensitive, personal and private nature of patients' perception of their own body weight, direct questions from healthcare professional may be perceived as judgmental or scolding, and may rapidly close down communication [11]. In this sensitive context, an anonymized online survey with a free word association task seems to be an optimal approach to scope group opinion [12].

Free word association is a widely used technique in market research and psychology to encourage respondents to express openly their underlying motivations, beliefs, attitudes or feelings regarding a specific topic [13]. This technique enhances the unconstrained expressions of respondents and overcomes limitations of predefined questionnaires.

We aimed to map the mental and emotional representation of the term *weight loss* in patients with obesity who had a documented interest in BS, using free word associations combined with a novel data-driven associative analytical method [12]. Further, we aimed to investigate the relationship between these representations and clinical parameters, such as stage of obesity and previous or planned experience with BS. We hypothesized that BS had a "positive" impact on the emotional labeling of *weight loss* related free word associations. Our findings may serve as basis to improve patient-centered communication strategies, online and in clinical practice alike [14].

Methods

We conducted an anonymized online survey to understand how adults with severe obesity (those who seek BS, postbariatric patients, and those who are not interested to undergo BS) perceive weight loss~~We conducted an anonymized online survey to understand how adults with obesity perceive weight loss~~. To ensure that participants are familiar with BS, respondents were recruited on a voluntary basis from bariatric surgery-related German-speaking social media groups between 02/11/2018 and 04/04/2018. An invitation for participation and three reminders every two weeks were posted on the 'Adipositas Zürich' (4100 followers) and 'Adipositas Chirurgie - Fragen und Antworten' (1500 followers) Facebook© groups, and respondents were encouraged to share the invitation within their own social networks. Thus, the survey was "open" to any respondents with a presumed interest in BS. We aimed to enroll a convenience sample of >500 respondents. The survey was administered via Typeform™ (Barcelona, Spain) (Supplemental Methods 1.), and only complete questionnaires could be submitted. Respondents could not be backtracked to a specific Facebook© profile. The Cantonal Ethics Committee of Zurich concluded that this study did not fall under the scope

of the Swiss Human Research Act, thus ethical approval was not required. The manuscript was prepared according to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) guidelines [15]. Network analyses were performed using Matlab 2017 (The Mathworks); logistic regressions and correlations were performed using R Software for Statistical Computing v3.5.2 (R Foundation, Vienna, Austria).

Building the dataset

Basic Demographics

Respondents were asked to self-report their age, sex, ethnicity, civil status, height, maximal and current body weight, past or planned bariatric operations, previous non-surgical weight loss attempts and their social interactions with bariatric patients. Body mass index (BMI) was calculated by the investigators based on the anthropometric data provided by the participants.

Free word associations

~~In addition to demographic questions, p~~Participants were asked to write five words, which first came to their mind about "weight loss". Further, they had to select two emotions from a list of 20 basic emotions (interest, anxiety, empathy, contempt, surprise, indifference, hope, fear, gratitude, anger, joy, sadness, calmness, frustration, pride, shame, generosity, envy, sympathy, antipathy) that best described their feelings about each of the five associations they provided [16, 17]. Emotional labeling was successfully applied ~~earlier~~ in a recent study to improve the interpretation of free-word associations by the addition of affective content [12].

Body image dissatisfaction (BID)

The color version of the reliable and validated Stunkard Figure Rating Scale was used to assess current and ideal body size estimations [18]. This instrument uses a series of 9 gender-specific silhouettes that gradually increase in body size. Although developed for normal weight adults with traditional eating disorders (e.g.: anorexia nervosa), this scale has been previously applied in the context of BS [19]. Respondents were instructed to select the figure that indicates (a) how they look currently and (b) how they would like to look like. A discrepancy score indicating *Body Image Dissatisfaction* (BID) was calculated by subtracting scores of the ideal figure (b) from the current (a) figure. Lower discrepancy scores were interpreted as lower body image dissatisfaction.

Data pre-processing

Response rate was calculated based on definitions and metrics proposed by the American Association for Public Opinion Research [20]. Respondents who provided incoherent data (i.e.: highest lifetime ~~body mass index (~~BMI~~)~~ < current BMI) or were found to be outside the target group (i.e.: highest lifetime BMI <35 kg/m^2, history of gastric banding, etc.) were excluded from the study cohort in a step-wise manner (Supplemental Fig. 1). Free word associations to "weight loss" were first spellchecked and lemmatized (i.e.: to return the base of a word) by two independent native German speakers. Associations were merged if their English translation was identical. Idiosyncratic expressions (associations with <9 occurrences) were left out.

Association network analysis

In order to extract the most prominent mental representations from the numerous individual associations provided by the respondents, we applied an in-house developed algorithm, using a network-based methodology validated and described earlier by our group [12]. To create such a

network, nodes (free word associations) and edges (statistical co-occurrences between two associations) were determined. Statistical co-occurrence was calculated by log-likelihood ratios (LLR). The LLR value can denote attractive (when two associations are often mentioned together) and repulsive connections (when two associations are rarely mentioned together) with a corresponding level of significance. In the network of statistically related associations, modularity maximization based consensus clustering algorithm was applied to explore any densely connected subnetworks (i.e.: modules) [21]. We have previously demonstrated that these modules of associations - as consistent patterns in individual association sequences – are able to capture the most prominent cognitive representation of a given cue [12]. Associations with weak module attachment were separately identified, since they may serve as bridges in future communicational strategies to simultaneously address individuals with different cognitive modular membership.

Qualitative and quantitative analysis of the map

First, we used descriptive statistics to characterize the subgroups of interests, as well as the members of the two cognitive modules. *Second*, we created explorative models by logistic regression to describe the relationship between free-word associations (cognitive module membership, emotional labels) and clinical parameters (stage of obesity, BS status, interest to undergo BS). The cognitive module of respondents was determined by the association cluster to which the majority of their associations belonged. Emotions were expressed as frequency (%) and the unfrequently (<4%) mentioned emotions were not included in the models to decrease false discovery rate. Respondents' current BMI status was dichotomized according to World Health Organisation obesity class II (≥/<35 kg/m^2), since this is the currently recommended cutoff for being eligible to BS [1]. We also created subgroups based on the BS status of respondents: "underwent BS", or in case of no previous BS,

"interested in BS" or "not interested in BS". Other frequently used demographic parameters (age, sex, ethnic origin) were not included in the explorative models, since they were equally distributed among subgroups and >93% of all respondents were adult Caucasian females. Nagelkerke's R^2 was used to express the coefficient of determination of the models.

Results

Respondents

Out of 2387 unique visits at the landing page, 1601 respondents completed the study (completion rate: 67.1%). The survey was mostly filled in via smartphones (82.5%), and took in average 6min20sec to complete. The final study cohort included 1482 respondents (Supplemental Table 1.).

Free word associations

The total number of unique associations was 1793. After the spellcheck, lemmatization and merging, the number of associations decreased to 235, out of which 84 were non-idiosyncratic and represented the basis of the network analysis. The co-occurring network of associations is presented in Fig. 1. Fig 2. presents the respective emotional labels, whereas respondents' characteristics are shown in Table 1. Postbariatric patients had a significantly higher proportion of positive emotional labels than non-operated adults with obesity (79% vs 75%, t(1480)=1.82; P = 0.002, d=0.18). We labeled the two cognitive modules as benefit- or procedure-focused, based on their most frequent associations. Significant attractive and repulsive connections between associations are presented visually in Supplemental Fig. 2. The associations with the lowest community attachment (measured by local modularity) were termed "bridging" associations, since they were frequently mentioned by

175 respondents of both groups (Supplemental Fig. 3). These included for example: “slim”, “excess skin” and “pride”. The association “new life” (most frequent emotional labels: joy, gratitude, hope, pride and surprise) resulted in a stand-alone module, which might represent the ultimate bridging association between the two cognitive modules.

Prediction models of BMI status, BS status and interest in BS

180 Results of the regression models are presented in Table 2. Respondents with a current ≥Class II obesity were more likely to have a benefit-focused perception of weight loss, to mention hope more frequently, and gratitude less frequently than respondents without severe obesity. Respondents who had undergone BS were more likely to belong to the procedure-focused cognitive module and to mention pride, surprise and especially gratitude more frequently than respondents without history of 185 BS. In the subgroup of respondents without previous BS, those who were interested in undergoing BS were more likely to express a benefit-focused mindset and use more frequently *hope* as emotional label.

Body Image Dissatisfaction

The BID score is presented according to the cognitive module membership in Table 1. Overall, 190 current BMI showed a) a strong correlation with BID (Pearson's r = 0.6, P < 0.001, Supplemental Fig. 4), b) an even stronger correlation with current body image (r = 0.77, P < 0.001) and c) a weaker correlation with the expected body image (r = 0.42, P < 0.001). ~~whereas s~~Sex-related differences were not identified (BID = 2.3±1.7 for females and 2.3±1.7 for males). Only 10.9% of all respondents (n = 162) were free of BID (score = 0).

Respondents who would not consider to undergo BS

Out of the 409 respondents without prior BS, 66 stated to have no interest to undergo BS. This subgroup had a mean age of 43.6 years and consisted of Caucasian (91%) females (92%) with a BID of 2.2 who managed to lose weight non-surgically (highest lifetime BMI: 45.4±8.3 kg/m^2, current BMI: 37.9±8.8 kg/m^2). Only 53% of this group had regular contact with BS patients.

Discussion

This study achieved data-driven interpretation of the perception of weight loss in a large cohort of adults, mainly Caucasian women, with obesity and/or history of BS. This is the first application of this novel, network-analysis based methodology in the context of BS, where patients' mindset and emotional demeanor play a cardinal role in therapeutic decision-making.

A major finding was that the perception of "weight loss" in adults with obesity formed two distinct mental representations or modules. Some respondents predominantly mentioned associations related to the procedure of weight loss (i.e.: *sport*, *diet*, *surgery*, *effort* and *sacrifice*), while others provided associations related to the benefits of weight loss (i.e.: *health*, *activity*, *agility*, *attractiveness, happiness* and *quality* or *joy of life*). In analogy to the latent class analysis of a recent study on patient preferences for BS [22], the larger module was labelled as *benefit-focused*, and the smaller as *procedure-focused*. The above-mentioned American study identified an additional, "cost-sensitive" mindset among BS candidates, however, in the current study, the financial burdens of BS were not mentioned. This is most likely explained by the inherent differences between the health-

insurance systems of German-speaking European countries and the complex structure of health-insurance coverage in the United States of America, where private funding is often involved. The most frequently mentioned association was "*health*", confirming from the patients' perspective the utmost importance of the metabolic effects of weight loss. Several associations highlighted the social pressure related to weight loss (i.e.: *social life, employment, normality, friendship, confidence, new life*). This observation complements the findings of a previous free-word association study in the context of obesity, in which healthy students had to provide their impressions on *fatness*. Surprisingly, they linked the fatness-related bad feelings with social pressure rather than with the health or self-comfort of the people with obesity [23].

Explorative models were used to test whether cognitive module membership was associated with previous or planned BS. Respondents with a history of BS adhered more frequently to the procedure-focused cognitive module, mirroring their pragmatic approach to weight loss. In contrast, those with an interest to undergo BS belonged more likely to the abstract, benefit-focused cognitive module. It has been shown earlier that abstract (vs. concrete) representations of ideal end-states are likely to influence engagement in a specific goal-oriented behavior [24]. In the context of obesity, optimistic expectations were previously shown to favor higher rates of successful weight loss following behavioral weight reduction [25]. However, unrealistic expectations can be responsible for the cycle of ~~repeated failures~~sub-optimal outcomes and renewed efforts to achieve self-change (i.e.: false-hope syndrome, "yo-yo effect")[26]. Therefore, the decision of undergoing BS may reflect a new approach to weight loss by patients who already experienced several unsuccessful conservative attempts to tackle obesity [1]. Although body image is an important indicator of patients' wellbeing after BS [27], BID ratings did not differ between the two cognitive modules, but showed a very

significant correlation with current BMI, and were higher in participants who planned to undergo BS, compared to those who did not, or already had BS.

Based on our findings, the emotional component may play a more important role than the cognitive component in the decision-making process of obese patients who seek to engage in new health behaviors. In line with our hypothesis, history of BS favored the use of positive emotional labels, however, the effect size was rather small. In fact, all respondents selected mainly positive emotions to label their associations. Remarkably, patients willing to undergo BS were more likely to express *hope*, while patients after BS expressed *gratitude* and *pride* more frequently, ~~suggests~~ suggesting that BS may fundamentally change the individuals' affective connection with weight loss. The emotional state of hope is forward-looking and may characterize both the procedures and the benefits related to a planned action, reflected by its equal distribution between the two cognitive modules [28]. Respondents with a ≥Class II obesity mentioned *hope* more frequently, reflecting their unmet need of achieving weight loss. In contrast, *gratitude* and *pride* were more frequently mentioned in the benefit-focused module and by those who already had BS and had a current BMI <35 kg/m^2. The feeling of gratitude is one of the most typical responses to perceived benevolence, which appears to foster prosocial behaviors and correlates with other factors of psychological well-being and agreeableness [29]. Pride is a subjective status-related emotion, which has a fundamental affective role in status seeking, attainment, and signaling [30]. According to a Brazilian study in patients experiencing postbariatric weight regain, the feeling of gratitude toward BS remained, whereas pride was replaced by a feeling of ~~failure~~ sub-optimal outcomes and low self-esteem [31]. *Peacock et al*. also found that the extent of emotional component in bariatric candidates' motivation (by comparing desperate patients ("have to") with those who expressed sentiment of being tired

("don't want to") or of pragmatism ("want to")) was associated with better postbariatric weight loss [8]. Subsequently, postoperative weight loss was shown to have a strong positive impact on patients' psychological well-being (including: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance), and even on marital satisfaction [32].

We acknowledge that associations are determined by a variety of personal experiences and future projections, and are not necessarily anchored to one single factor (such as BMI or BS). Nevertheless, this study provided a comprehensive structure of ~~obese individuals'~~adults' with obesity free expressions about weight loss, enhancing our understanding of patients' priorities and ~~may~~ contribute~~e~~ing to the improvement of health care-related communicational schemes. Discrepant expectations may significantly increase postoperative dissatisfaction with body image and decrease the extent of achievable weight loss [33], therefore setting realistic preoperative expectations and stepwise postoperative goals are crucial. Our findings also promote the collaborative approach between healthcare providers to support evidence-based treatments of obesity [34]. Focusing on the *consumer value* is the first principle of the *lean thinking* health care management method [35]. Association network models have been proven suitable for studying consumer-based brand equity by identifying relevant "character traits" which may assist the optimization of current processes [36]. In the context of BS, *Powell et al.* showed that psychological skills interventions can be implemented successfully to improve postbariatric patients' participation in exercise programs [37]. Consequently, the network-based map of associations to weight loss presented in this study may serve as a navigational tool for caregivers, policy actors and researchers to better identify patients' implicit interest toward weight loss and to design new interventions aiming to tackle mindset barriers in the acceptance of BS among patients with obesity [38]. Our findings suggest that complementing factual

information on BS with emotional experiences of postbariatric patients (i.e.: gratitude and pride) and emphasizing the benefits rather than the procedural aspects of achieving weight loss may be effective in changing perspectives on life-priorities of people with obesity. As there is a growing interest for health-related information on multiple digital platforms, including social media, the relevant positioning of "weight loss" can influence large groups of people with obesity and change social norms [39]. Once a mindset has been primed or activated, there is an increased likelihood that it will be used in upcoming tasks to interpret new information and to define subsequent actions [24]. A subgroup of the respondents stated not to be interested to undergo BS, nevertheless, by following BS-related social media they manifested interest towards BS and seem to be seeking facts and/or patient narratives to assist their health-related decisions.

The main limitation of the study derives from the inherent methodologic bias of internet-based surveys: 1) the non-representative nature of the Internet population and 2) the self-selection of participants (volunteer effect) [15]. These factors may explain the very high proportion of Caucasian females with previous BS within all respondents. In the absence of longitudinal data collection, demographic parameters – especially current BMI – are likely to confound the relationship of BS and cognitive module membership. Although there are techniques to account for the effect of BMI (i.e.: propensity-score matching), we aimed to demonstrate real-world scenarios where the stage of obesity and BS history are strongly interconnected. The lack of directly measured BMI values represent an additional imperfection. Nevertheless, self-reported height and weight were found to highly correlate with measured values (R ≥0.9) in the Danish Health Survey [40].

Conclusion

The combination of research methods (data-driven cross-network analysis of free associations with emotional valence and use of validated psychologic questionnaire) was synergistic in mapping patients' motivational drivers, beliefs, attitudes or feelings towards weight loss. Respondents with severe obesity and those planning to undergo BS are more likely to be benefit-focused and to express "hope", compared to their slimmer postbariatric peers, who are more often procedure-focused, feel "gratitude" and "pride" more often and suffer less from body image dissatisfaction. Emotional and mental schemes stemming from patients' free associations may enrich the informed consent process prior to BS and could serve as basis for the development of novel communicational strategies between health-care providers and patients with obesity.

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Disclosure: The authors declare no conflict of interest. Prof. **Blinded** reports personal fees from Johnson & Johnson and Medtronic, outside the submitted work.

Ethical approval

The Cantonal Ethics Committee of Zurich stated that the study did not fall under the scope of the Swiss Human Research Act, and consequently, does not need ethical approval (BASEC-Nr. Req-2017-00903).

Tables

Table 1. Respondents' characteristics according to cognitive module membership. *BMI: Body Mass Index. BS: bariatric surgery. *: significant (P < 0.01) difference in the frequency of the emotion between the two modules.*

Table 2. Explorative models using logistic regression investigating the effect of the stage of obesity and of bariatric surgery status on cognitive module membership and use of different emotional labels. *CI: confidence interval, BMI: body mass index, BS: bariatric surgery*

A. Respondents with ≥WHO Class II Obesity *vs*. Respondents with <WHO Class II Obesity (= reference). Based on the entire cohort [n = 1482; R^2 = 0.156]

B. Respondents who underwent bariatric surgery *vs.* Respondents without history of bariatric surgery (= reference). Based on the entire cohort [n = 1482, R^2 = 0.169]

C. Respondents with an interest to undergo bariatric surgery *vs.* Respondents not interested to undergo bariatric surgery (= reference). Within the subgroup of respondents without history of bariatric surgery [n = 409; R^2 = 0.142]

Figures

Figure 1. Free-word association networks to "weight loss" in patients with obesity. The modules reflect the data-driven frequency of co-occurrences of associations. Potential interpretation: *Green: benefit-focused mindset; Purple: procedure-focused mindset.*

Figure 2. Frequency of emotional labels assigned to the associations of each cognitive module

Supplemental Material

Supplemental Methods

Supplemental Method 1. The survey as it was presented to the participants (MethodS1.pdf)

Supplemental Table

Supplemental Table 1.

A. Descriptive characteristics of the respondents based on their current stage of obesity and on their bariatric surgery status. *BMI: body mass index*

B. Comparison of demographic parameters between subgroups

~~Descriptive characteristics of the respondents based on their current stage of obesity and on their bariatric surgery status. *BMI: body mass index*~~

Supplemental Figures

Supplemental Figure 1. Flowchart of the selection of the study cohort

Supplemental Figure 2. Attractive and repulsive associations

Supplemental Figure 3. Bridging associations

Supplemental Figure 4. Correlation of current BMI and Body Image Dissatisfaction

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Title

Mental and emotional representations of “weight loss”: free-word association networks in members of bariatric surgery-related social media communities

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Running title: Mental and emotional representations of weight loss

Abstract

Background: Mindset and communication barriers may hinder the acceptance of bariatric surgery (BS) by the eligible patient population.

Objectives: To improve the understanding of expectations, opinions, emotions and attitudes toward weight-loss among patients with obesity.

Setting: Switzerland, Germany, Austria.

Methods: Survey data collected from BS-related social media communities (N=1482). Participants were asked to write 5 words that first came to their mind about "weight loss", and to select 2 emotions which best described their corresponding feelings. Demographic and obesity-related data were collected. Cognitive representations were constructed based on the co-occurrence network of associations, using validated data-driven methodology.

Results: Respondents were Caucasian (98%), female (94%), aged 42.5±10.1 years, current/highest lifetime body mass index=36.9±9/50.7±8.7 kg/m^2. The association network analysis revealed two cognitive modules: benefit-focused (health, attractiveness, happiness, agility) and procedure-focused (effort, diet, sport, surgery). Patients willing to undergo BS were more benefit-focused (Odds ratio (OR)=2.4, P=0.02) and expressed more 'hope' (OR=142, P<0.001). History of BS was associated with higher adherence to the procedure-focused module (OR=2.3, P<0.001), and with increased use of the emotions 'gratitude' (OR=107, P<0.001), 'pride' (OR=15, P<0.001), and decreased mention of 'hope' (OR=0.03, P<0.001).

Conclusion: Patients with obesity in our study tend to think about weight loss along two cognitive schemes, either emphasizing its expected benefits or focusing on the process of achieving it. Benefit-focused respondents were more likely to consider BS, and to express hope rather than gratitude or pride. Novel communication strategies may increase the acceptance of BS by incorporating weight loss-related cognitive and emotional content stemming from patients' free associations.

Keywords

Bariatric Surgery; Weight loss; Free-word Association; Network; Obesity; Emotional valence; Mindset; Motivation; Body image dissatisfaction

Introduction

Bariatric surgery (BS) is currently the most effective modality in the treatment of severe obesity and related diseases [1]. Despite its growing worldwide popularity as a treatment option, BS is rather underused by the eligible patient population [2]. Mindset and communication barriers seem to influence the diffusion of BS: lack of information, incorrect information, and stigmatization of individuals with obesity have proven to contribute to sub-optimal use of health care by the eligible patients and to insufficient cooperation between primary care physicians and BS centers [3, 4]. This may also hinder the identification and referral of eligible patients and undermine optimal postbariatric follow-up [4].

Available literature on motivational drivers in favor of seeking BS remains scarce and stems mainly from small cohorts [5-7]. Nevertheless, corroborative evidence shows that the willingness to improve health is the cornerstone for seeking BS, contextualized with psychological, emotional, environmental and social factors [8, 9]. Within the developing framework of person-centered care, the patients' narrative is a key factor in improving decision-making [10]. However, due to the sensitive, personal and private nature of patients' perception of their own body weight, direct questions from healthcare professional may be perceived as judgmental or scolding, and may rapidly close down communication [11]. In this sensitive context, an anonymized online survey with a free word association task seems to be an optimal approach to scope group opinion [12].

Free word association is a widely used technique in market research and psychology to encourage respondents to express openly their underlying motivations, beliefs, attitudes or feelings regarding a specific topic [13]. This technique enhances the unconstrained expressions of respondents and overcomes limitations of predefined questionnaires.

We aimed to map the mental and emotional representation of the term *weight loss* in patients with obesity who had a documented interest in BS, using free word associations combined with a novel data-driven associative analytical method [12]. Further, we aimed to investigate the relationship between these representations and clinical parameters, such as stage of obesity and previous or planned experience with BS. We hypothesized that BS had a "positive" impact on the emotional labeling of *weight loss* related free word associations. Our findings may serve as basis to improve patient-centered communication strategies, online and in clinical practice alike [14].

Methods

We conducted an anonymized online survey to understand how adults with severe obesity (those who seek BS, postbariatric patients, and those who are not interested to undergo BS) perceive weight loss. To ensure that participants are familiar with BS, respondents were recruited on a voluntary basis from bariatric surgery-related German-speaking social media groups between 02/11/2018 and 04/04/2018. An invitation for participation and three reminders every two weeks were posted on the 'Adipositas Zürich' (4100 followers) and 'Adipositas Chirurgie - Fragen und Antworten' (1500 followers) Facebook© groups, and respondents were encouraged to share the invitation within their own social networks. Thus, the survey was "open" to any respondents with a presumed interest in BS. We aimed to enroll a convenience sample of >500 respondents. The survey was administered via Typeform™ (Barcelona, Spain) (Supplemental Methods 1.), and only complete questionnaires could be submitted. Respondents could not be backtracked to a specific Facebook© profile. The Cantonal Ethics Committee of Zurich concluded that this study did not fall under the scope of the Swiss Human Research Act, thus ethical approval was not required. The manuscript was

prepared according to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) guidelines [15]. Network analyses were performed using Matlab 2017 (The Mathworks); logistic regressions and correlations were performed using R Software for Statistical Computing v3.5.2 (R Foundation, Vienna, Austria).

Building the dataset

Basic Demographics

Respondents were asked to self-report their age, sex, ethnicity, civil status, height, maximal and current body weight, past or planned bariatric operations, previous non-surgical weight loss attempts and their social interactions with bariatric patients. Body mass index (BMI) was calculated by the investigators based on the anthropometric data provided by the participants.

Free word associations

Participants were asked to write five words, which first came to their mind about "weight loss". Further, they had to select two emotions from a list of 20 basic emotions (interest, anxiety, empathy, contempt, surprise, indifference, hope, fear, gratitude, anger, joy, sadness, calmness, frustration, pride, shame, generosity, envy, sympathy, antipathy) that best described their feelings about each of the five associations they provided [16, 17]. Emotional labeling was successfully applied in a recent study to improve the interpretation of free-word associations by the addition of affective content [12].

Body image dissatisfaction (BID)

The color version of the reliable and validated Stunkard Figure Rating Scale was used to assess current and ideal body size estimations [18]. This instrument uses a series of 9 gender-specific

silhouettes that gradually increase in body size. Although developed for normal weight adults with traditional eating disorders (e.g.: anorexia nervosa), this scale has been previously applied in the context of BS [19]. Respondents were instructed to select the figure that indicates (a) how they look currently and (b) how they would like to look like. A discrepancy score indicating *Body Image Dissatisfaction* (BID) was calculated by subtracting scores of the ideal figure (b) from the current (a) figure. Lower discrepancy scores were interpreted as lower body image dissatisfaction.

Data pre-processing

Response rate was calculated based on definitions and metrics proposed by the American Association for Public Opinion Research [20]. Respondents who provided incoherent data (i.e.: highest lifetime BMI < current BMI) or were found to be outside the target group (i.e.: highest lifetime BMI <35 kg/m^2, history of gastric banding, etc.) were excluded from the study cohort in a step-wise manner (Supplemental Fig. 1). Free word associations to "weight loss" were first spellchecked and lemmatized (i.e.: to return the base of a word) by two independent native German speakers. Associations were merged if their English translation was identical. Idiosyncratic expressions (associations with <9 occurrences) were left out.

Association network analysis

In order to extract the most prominent mental representations from the numerous individual associations provided by the respondents, we applied an in-house developed algorithm, using a network-based methodology validated and described earlier by our group [12]. To create such a network, nodes (free word associations) and edges (statistical co-occurrences between two associations) were determined. Statistical co-occurrence was calculated by log-likelihood ratios (LLR).

The LLR value can denote attractive (when two associations are often mentioned together) and repulsive connections (when two associations are rarely mentioned together) with a corresponding level of significance. In the network of statistically related associations, modularity maximization based consensus clustering algorithm was applied to explore any densely connected subnetworks (i.e.: modules) [21]. We have previously demonstrated that these modules of associations - as consistent patterns in individual association sequences – are able to capture the most prominent cognitive representation of a given cue [12]. Associations with weak module attachment were separately identified, since they may serve as bridges in future communicational strategies to simultaneously address individuals with different cognitive modular membership.

Qualitative and quantitative analysis of the map

First, we used descriptive statistics to characterize the subgroups of interests, as well as the members of the two cognitive modules. *Second*, we created explorative models by logistic regression to describe the relationship between free-word associations (cognitive module membership, emotional labels) and clinical parameters (stage of obesity, BS status, interest to undergo BS). The cognitive module of respondents was determined by the association cluster to which the majority of their associations belonged. Emotions were expressed as frequency (%) and the unfrequently (<4%) mentioned emotions were not included in the models to decrease false discovery rate. Respondents' current BMI status was dichotomized according to World Health Organisation obesity class II (≥/<35 kg/m^2), since this is the currently recommended cutoff for being eligible to BS [1]. We also created subgroups based on the BS status of respondents: "underwent BS", or in case of no previous BS, "interested in BS" or "not interested in BS". Other frequently used demographic parameters (age, sex, ethnic origin) were not included in the explorative models, since they were equally distributed among

subgroups and >93% of all respondents were adult Caucasian females. Nagelkerke's R^2 was used to express the coefficient of determination of the models.

Results

Respondents

Out of 2387 unique visits at the landing page, 1601 respondents completed the study (completion rate: 67.1%). The survey was mostly filled in via smartphones (82.5%), and took in average 6min20sec to complete. The final study cohort included 1482 respondents (Supplemental Table 1.).

Free word associations

The total number of unique associations was 1793. After the spellcheck, lemmatization and merging, the number of associations decreased to 235, out of which 84 were non-idiosyncratic and represented the basis of the network analysis. The co-occurring network of associations is presented in Fig. 1. Fig 2. presents the respective emotional labels, whereas respondents' characteristics are shown in Table 1. Postbariatric patients had a significantly higher proportion of positive emotional labels than non-operated adults with obesity (79% vs 75%, t(1480)=1.82; P = 0.002, d=0.18). We labeled the two cognitive modules as benefit- or procedure-focused, based on their most frequent associations. Significant attractive and repulsive connections between associations are presented visually in Supplemental Fig. 2. The associations with the lowest community attachment (measured by local modularity) were termed "bridging" associations, since they were frequently mentioned by respondents of both groups (Supplemental Fig. 3). These included for example: "slim", "excess skin" and "pride". The association "new life" (most frequent emotional labels: joy, gratitude, hope, pride

and surprise) resulted in a stand-alone module, which might represent the ultimate bridging association between the two cognitive modules.

Prediction models of BMI status, BS status and interest in BS

Results of the regression models are presented in Table 2. Respondents with a current ≥Class II obesity were more likely to have a benefit-focused perception of weight loss, to mention hope more frequently, and gratitude less frequently than respondents without severe obesity. Respondents who had undergone BS were more likely to belong to the procedure-focused cognitive module and to mention pride, surprise and especially gratitude more frequently than respondents without history of BS. In the subgroup of respondents without previous BS, those who were interested in undergoing BS were more likely to express a benefit-focused mindset and use more frequently *hope* as emotional label.

Body Image Dissatisfaction

The BID score is presented according to the cognitive module membership in Table 1. Overall, current BMI showed a) a strong correlation with BID (Pearson's r = 0.6, P < 0.001, Supplemental Fig. 4), b) an even stronger correlation with current body image (r = 0.77, P < 0.001) and c) a weaker correlation with the expected body image (r = 0.42, P < 0.001). Sex-related differences were not identified (BID = 2.3±1.7 for females and 2.3±1.7 for males). Only 10.9% of all respondents (n = 162) were free of BID (score = 0).

Respondents who would not consider to undergo BS

Out of the 409 respondents without prior BS, 66 stated to have no interest to undergo BS. This subgroup had a mean age of 43.6 years and consisted of Caucasian (91%) females (92%) with a BID of 2.2 who managed to lose weight non-surgically (highest lifetime BMI: 45.4±8.3 kg/m^2, current BMI: 37.9±8.8 kg/m^2). Only 53% of this group had regular contact with BS patients.

Discussion

This study achieved data-driven interpretation of the perception of weight loss in a large cohort of adults, mainly Caucasian women, with obesity and/or history of BS. This is the first application of this novel, network-analysis based methodology in the context of BS, where patients' mindset and emotional demeanor play a cardinal role in therapeutic decision-making.

A major finding was that the perception of "weight loss" in adults with obesity formed two distinct mental representations or modules. Some respondents predominantly mentioned associations related to the procedure of weight loss (i.e.: *sport*, *diet*, *surgery*, *effort* and *sacrifice*), while others provided associations related to the benefits of weight loss (i.e.: *health*, *activity*, *agility*, *attractiveness, happiness* and *quality* or *joy of life*). In analogy to the latent class analysis of a recent study on patient preferences for BS [22], the larger module was labelled as *benefit-focused*, and the smaller as *procedure-focused*. The above-mentioned American study identified an additional, "cost-sensitive" mindset among BS candidates, however, in the current study, the financial burdens of BS were not mentioned. This is most likely explained by the inherent differences between the health-

insurance systems of German-speaking European countries and the complex structure of health-insurance coverage in the United States of America, where private funding is often involved. The most frequently mentioned association was "*health*", confirming from the patients' perspective the utmost importance of the metabolic effects of weight loss. Several associations highlighted the social pressure related to weight loss (i.e.: *social life, employment, normality, friendship, confidence, new life*). This observation complements the findings of a previous free-word association study in the context of obesity, in which healthy students had to provide their impressions on *fatness*. Surprisingly, they linked the fatness-related bad feelings with social pressure rather than with the health or self-comfort of the people with obesity [23].

Explorative models were used to test whether cognitive module membership was associated with previous or planned BS. Respondents with a history of BS adhered more frequently to the procedure-focused cognitive module, mirroring their pragmatic approach to weight loss. In contrast, those with an interest to undergo BS belonged more likely to the abstract, benefit-focused cognitive module. It has been shown earlier that abstract (vs. concrete) representations of ideal end-states are likely to influence engagement in a specific goal-oriented behavior [24]. In the context of obesity, optimistic expectations were previously shown to favor higher rates of successful weight loss following behavioral weight reduction [25]. However, unrealistic expectations can be responsible for the cycle of sub-optimal outcomes and renewed efforts to achieve self-change (i.e.: false-hope syndrome, "yo-yo effect")[26]. Therefore, the decision of undergoing BS may reflect a new approach to weight loss by patients who already experienced several unsuccessful conservative attempts to tackle obesity [1]. Although body image is an important indicator of patients' wellbeing after BS [27], BID ratings did not differ between the two cognitive modules, but showed a very

significant correlation with current BMI, and were higher in participants who planned to undergo BS, compared to those who did not, or already had BS.

Based on our findings, the emotional component may play a more important role than the cognitive component in the decision-making process of obese patients who seek to engage in new health behaviors. In line with our hypothesis, history of BS favored the use of positive emotional labels, however, the effect size was rather small. In fact, all respondents selected mainly positive emotions to label their associations. Remarkably, patients willing to undergo BS were more likely to express *hope*, while patients after BS expressed *gratitude* and *pride* more frequently, suggesting that BS may fundamentally change the individuals' affective connection with weight loss. The emotional state of hope is forward-looking and may characterize both the procedures and the benefits related to a planned action, reflected by its equal distribution between the two cognitive modules [28]. Respondents with a ≥Class II obesity mentioned *hope* more frequently, reflecting their unmet need of achieving weight loss. In contrast, *gratitude* and *pride* were more frequently mentioned in the benefit-focused module and by those who already had BS and had a current BMI <35 kg/m^2. The feeling of gratitude is one of the most typical responses to perceived benevolence, which appears to foster prosocial behaviors and correlates with other factors of psychological well-being and agreeableness [29]. Pride is a subjective status-related emotion, which has a fundamental affective role in status seeking, attainment, and signaling [30]. According to a Brazilian study in patients experiencing postbariatric weight regain, the feeling of gratitude toward BS remained, whereas pride was replaced by a feeling of sub-optimal outcomes and low self-esteem [31]. *Peacock et al*. also found that the extent of emotional component in bariatric candidates' motivation (by comparing desperate patients ("have to") with those who expressed sentiment of being tired ("don't want to") or of pragmatism

("want to")) was associated with better postbariatric weight loss [8]. Subsequently, postoperative weight loss was shown to have a strong positive impact on patients' psychological well-being (including: autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self-acceptance), and even on marital satisfaction [32].

We acknowledge that associations are determined by a variety of personal experiences and future projections, and are not necessarily anchored to one single factor (such as BMI or BS). Nevertheless, this study provided a comprehensive structure of adults' with obesity free expressions about weight loss, enhancing our understanding of patients' priorities and contributing to the improvement of health care-related communicational schemes. Discrepant expectations may significantly increase postoperative dissatisfaction with body image and decrease the extent of achievable weight loss [33], therefore setting realistic preoperative expectations and stepwise postoperative goals are crucial. Our findings also promote the collaborative approach between healthcare providers to support evidence-based treatments of obesity [34]. Focusing on the *consumer value* is the first principle of the *lean thinking* health care management method [35]. Association network models have been proven suitable for studying consumer-based brand equity by identifying relevant "character traits" which may assist the optimization of current processes [36]. In the context of BS, *Powell et al.* showed that psychological skills interventions can be implemented successfully to improve postbariatric patients' participation in exercise programs [37]. Consequently, the network-based map of associations to weight loss presented in this study may serve as a navigational tool for caregivers, policy actors and researchers to better identify patients' implicit interest toward weight loss and to design new interventions aiming to tackle mindset barriers in the acceptance of BS among patients with obesity [38]. Our findings suggest that complementing factual information on BS with

emotional experiences of postbariatric patients (i.e.: gratitude and pride) and emphasizing the benefits rather than the procedural aspects of achieving weight loss may be effective in changing perspectives on life-priorities of people with obesity. As there is a growing interest for health-related information on multiple digital platforms, including social media, the relevant positioning of "weight loss" can influence large groups of people with obesity and change social norms [39]. Once a mindset has been primed or activated, there is an increased likelihood that it will be used in upcoming tasks to interpret new information and to define subsequent actions [24]. A subgroup of the respondents stated not to be interested to undergo BS, nevertheless, by following BS-related social media they manifested interest towards BS and seem to be seeking facts and/or patient narratives to assist their health-related decisions.

The main limitation of the study derives from the inherent methodologic bias of internet-based surveys: 1) the non-representative nature of the Internet population and 2) the self-selection of participants (volunteer effect) [15]. These factors may explain the very high proportion of Caucasian females with previous BS within all respondents. In the absence of longitudinal data collection, demographic parameters – especially current BMI – are likely to confound the relationship of BS and cognitive module membership. Although there are techniques to account for the effect of BMI (i.e.: propensity-score matching), we aimed to demonstrate real-world scenarios where the stage of obesity and BS history are strongly interconnected. The lack of directly measured BMI values represent an additional imperfection. Nevertheless, self-reported height and weight were found to highly correlate with measured values ($R \geq 0.9$) in the Danish Health Survey [40].

Conclusion

The combination of research methods (data-driven cross-network analysis of free associations with emotional valence and use of validated psychologic questionnaire) was synergistic in mapping patients' motivational drivers, beliefs, attitudes or feelings towards weight loss. Respondents with severe obesity and those planning to undergo BS are more likely to be benefit-focused and to express "hope", compared to their slimmer postbariatric peers, who are more often procedure-focused, feel "gratitude" and "pride" more often and suffer less from body image dissatisfaction. Emotional and mental schemes stemming from patients' free associations may enrich the informed consent process prior to BS and could serve as basis for the development of novel communicational strategies between health-care providers and patients with obesity.

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Disclosure: The authors declare no conflict of interest. Prof. **Blinded** reports personal fees from Johnson & Johnson and Medtronic, outside the submitted work.

Ethical approval

The Cantonal Ethics Committee of Zurich stated that the study did not fall under the scope of the Swiss Human Research Act, and consequently, does not need ethical approval (BASEC-Nr. Req-2017-00903).

Tables

Table 1. Respondents' characteristics according to cognitive module membership. *BMI: Body Mass Index. BS: bariatric surgery. *: significant (P < 0.01) difference in the frequency of the emotion between the two modules.*

Table 2. Explorative models using logistic regression investigating the effect of the stage of obesity and of bariatric surgery status on cognitive module membership and use of different emotional labels. *CI: confidence interval, BMI: body mass index, BS: bariatric surgery*

A. Respondents with ≥WHO Class II Obesity *vs*. Respondents with <WHO Class II Obesity (= reference). Based on the entire cohort [n = 1482; R^2 = 0.156]

B. Respondents who underwent bariatric surgery *vs.* Respondents without history of bariatric surgery (= reference). Based on the entire cohort [n = 1482, R^2 = 0.169]

C. Respondents with an interest to undergo bariatric surgery *vs.* Respondents not interested to undergo bariatric surgery (= reference). Within the subgroup of respondents without history of bariatric surgery [n = 409; R^2 = 0.142]

Figures

Figure 1. Free-word association networks to "weight loss" in patients with obesity. The modules reflect the data-driven frequency of co-occurrences of associations. Potential interpretation: *Green: benefit-focused mindset; Purple: procedure-focused mindset.*

Figure 2. Frequency of emotional labels assigned to the associations of each cognitive module

Supplemental Material

Supplemental Methods

Supplemental Method 1. The survey as it was presented to the participants (MethodS1.pdf)

Supplemental Table

Supplemental Table 1.

A. Descriptive characteristics of the respondents based on their current stage of obesity and on their bariatric surgery status. *BMI: body mass index*

B. Comparison of demographic parameters between subgroups

Supplemental Figures

Supplemental Figure 1. Flowchart of the selection of the study cohort

Supplemental Figure 2. Attractive and repulsive associations

Supplemental Figure 3. Bridging associations

Supplemental Figure 4. Correlation of current BMI and Body Image Dissatisfaction

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Tables

Table 1. Respondents' characteristics according to cognitive module membership. *BMI: Body Mass Index. BS: bariatric surgery. *: significant (P<0.01) difference in the frequency of the emotion between the two modules.*

	Module of associations		
	Benefit-focused	**Procedure-focused**	**P**
n	1174	253	
Age (mean, SD)	43.1 ± 10.8	40.4 ± 10.2	< 0.001
Female (%)	94.5	92.5	1
Relationship status (%)			0.22
single	15	17	
divorced	11	8	
in relation	22	26	
married	50	48	
widow	2	2	
Current BMI ≥35 kg/m^2 (%)	54.1	43.1	0.002
Maximal lifetime BMI (mean, SD)	50.7 ± 8.5	50.3 ± 9.2	0.51
Body Image Dissatisfaction (mean, SD)	2.3 ± 1.7	2.2 ± 1.5	0.52
Proportion of positive emotions (%)	86 ± 19	47 ± 27	< 0.001
Had bariatric surgery (%)	71.7	76.3	0.14
Among those who did not have BS:			
Interested in undergoing BS (%)	87	66.7	< 0.001
Most frequent associations (%)			
1st	health (54)	sport (17)	
2nd	agility (24)	diet (14)	
3rd	attractiveness (24)	effort (9)	
4th	happiness (21)	excess skin (5)	
5th	activity (21)	sacrifice (4)	
Most frequently associated emotions (%)			
1st	joy (21) *	hope (13) *	
2nd	gratitude (17) *	frustration (13) *	
3rd	hope (17) *	anxiety (11) *	
4th	pride (12) *	interest (9)	
5th	interest (7)	joy (7) *	

Table 2. Explorative models using logistic regression investigating the effect of the stage of obesity and of bariatric surgery status on cognitive module membership and use of different emotional labels. *CI: confidence interval, BMI: body mass index BS: bariatric surgery*

A. Respondents with ≥WHO Class II Obesity *vs*. Respondents with <WHO Class II Obesity (= reference). Based on the entire cohort [n = 1482; R^2 = 0.156]

	Respondents with ≥Class II obesity			
	Odds ratio	*95% CI*		*P*
Benefit-focused cognitive module	*2.2*	*1.6*	*3.1*	*<0.001*
Joy	1.4	0.5	4.2	0.5
Hope	*76.6*	*25.7*	*227.8*	*<0.001*
Gratitude	*0.04*	*0.01*	*0.1*	*<0.001*
Pride	*0.2*	*0.06*	*0.7*	*0.01*
Interest	0.4	0.1	1.4	0.14
Anxiety	0.7	0.2	4.9	0.96
Surprise	*0.2*	*0.04*	*0.9*	*0.04*
Frustration	1.6	0.3	9.4	0.63

B. Respondents who underwent bariatric surgery *vs.* Respondents without history of bariatric surgery (= reference). Based on the entire cohort [n = 1482, R^2 = 0.169]

	Respondents with prior bariatric surgery			
	Odds ratio	*95% CI*		*P*
Benefit-focused cognitive module	*0.4*	*0.3*	*0.6*	*<0.001*
Joy	0.5	0.2	1.8	0.3
Hope	*0.03*	*0.01*	*0.1*	*<0.001*
Gratitude	*107.8*	*27.7*	*420.2*	*<0.001*
Pride	*15.6*	*3.4*	*69.2*	*<0.001*
Interest	1	0.3	3.5	0.99
Anxiety	0.6	0.1	3.6	0.6
Surprise	*7.2*	*1.2*	*45*	*0.04*
Frustration	0.2	0.03	1.2	0.08

C. Respondents with an interest to undergo bariatric surgery *vs.* Respondents not interested to undergo bariatric surgery (= reference). Within the subgroup of respondents without history of bariatric surgery [n = 409; R^2 = 0.142]

	Respondent with an interest to undergo bariatric surgery			
	Odds ratio	*95% CI*		*P*
Benefit-focused cognitive module	*2.4*	*1.17*	*4.94*	*0.02*
Joy	0.9	0.06	15.2	0.96
Hope	*142.5*	*9.9*	*2047.1*	*<0.001*
Gratitude	1.2	0.06	26	0.9
Pride	0.3	0.01	9.2	0.5
Interest	0.1	0.01	1.8	0.12
Anxiety	5.3	0.1	276.7	0.41
Surprise	4.3	0.06	328.7	0.51
Frustration	0.8	0.02	47	0.93

Figure 1.

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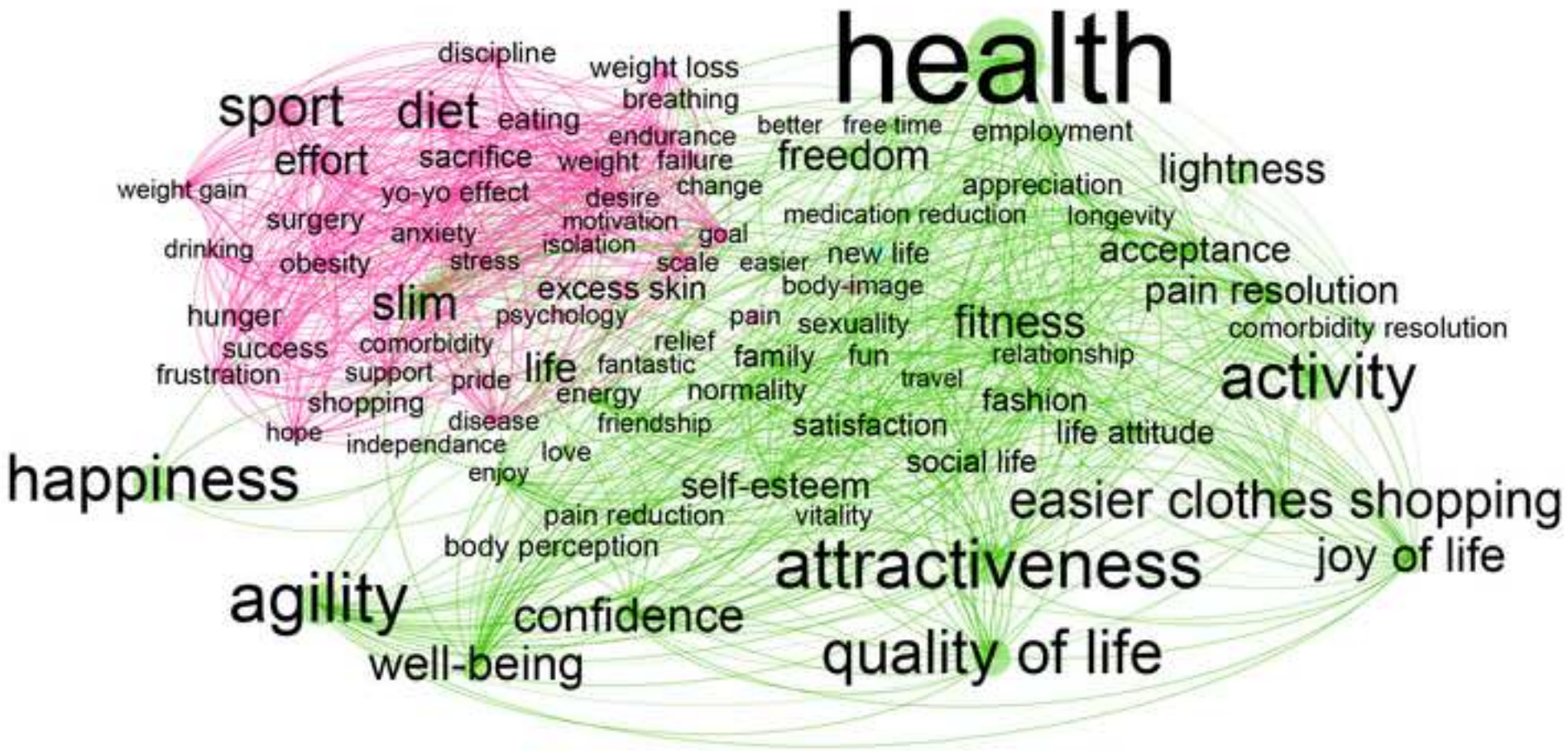

Figure 2.

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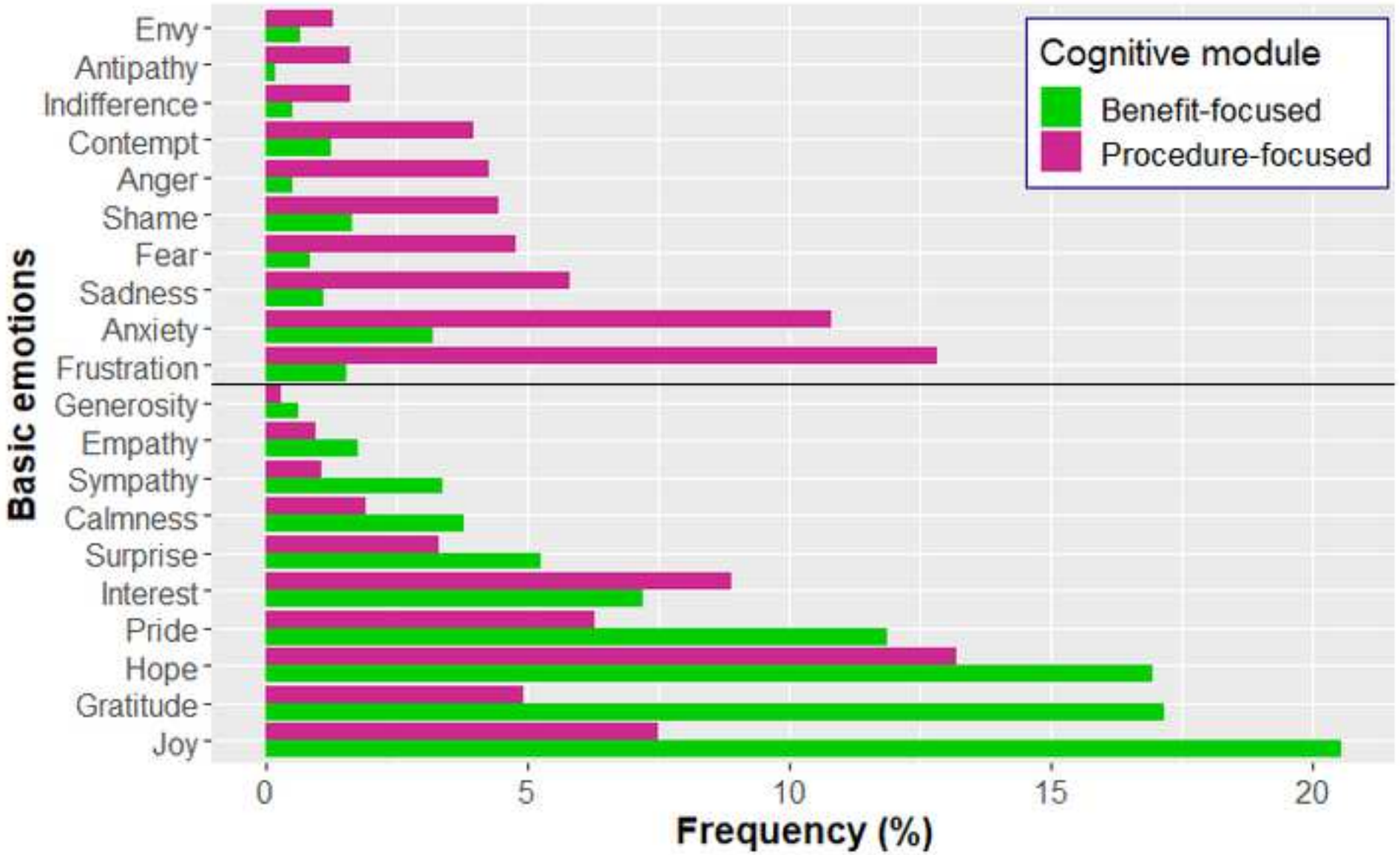

Gero, File, et al. Mental and emotional representations of "weight loss": free-word association networks in members of bariatric surgery-related social media communities. S*URGERY FOR OBESITY AND RELATED DISEASES. 2019*

Highlights

- Aim to map mental and emotional representation of *weight loss* in bariatric patients
- 1st application of a novel network-analysis based methodology in the context of BS
- 1482 patients were surveyed within bariatric social media communities
- Patients think about weight loss in two cognitive schemes: benefit/process focused
- Benefit-focused respondents were more likely to consider bariatric surgery
- Novel communication strategies may incorporate the patients' free associations